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Leclercq et al.

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(54) **METHOD AND SYSTEM FOR REPURPOSING OF A GLOBAL NAVIGATION SATELLITE SYSTEM RECEIVER FOR RECEIVING LOW-EARTH ORBIT COMMUNICATION SATELLITE SIGNALS**

(75) Inventors: **Maxime Leclercq**, Encinitas, CA (US); **Ioannis Spyropoulos**, La Jolla, CA (US); **Nishant Kumar**, San Diego, CA (US); **Anand Anandakumar**, San Diego, CA (US)

(73) Assignee: **Maxlinear, Inc.**, Carlsbad, CA (US)

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(22) Filed: **Mar. 7, 2012**

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H04B 7/185 (2006.01)

(52) **U.S. Cl.**
CPC ***H04B 7/18547*** (2013.01); ***H04B 7/1853*** (2013.01)

(58) **Field of Classification Search**
CPC G01S 19/28; G01S 19/42; G01S 13/878; H04B 7/18508
USPC 342/352, 357.2, 357.21, 357.25, 357.4; 455/12.1, 13.2; 375/144
See application file for complete search history.

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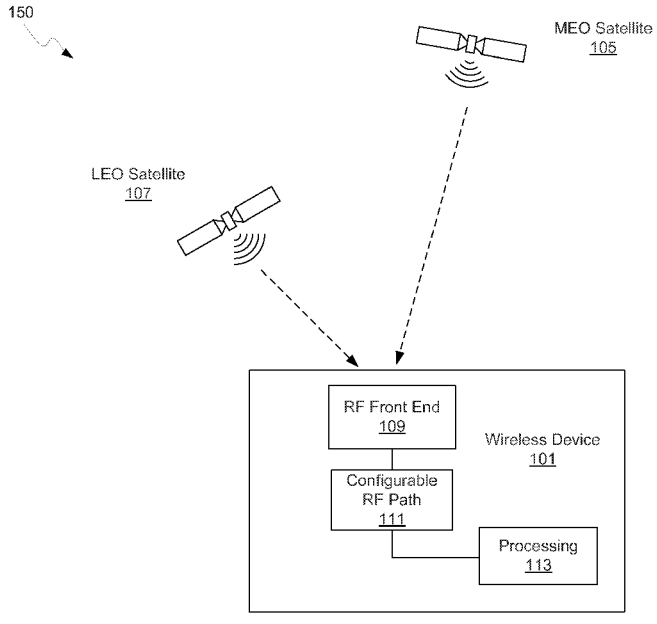
Primary Examiner — Dao Phan
(74) *Attorney, Agent, or Firm* — McAndrews, Held & Malloy

(57) **ABSTRACT**

Methods and systems for repurposing of a global navigation satellite system receiver for receiving low-earth orbit (LEO) communication satellite timing signals may comprise receiving medium Earth orbit (MEO) satellite signals and/or LEO signals in a receiver of the communication device. A radio frequency (RF) path may be configured to down-convert either of the signals, and a position of the communication device may be calculated utilizing the down-converted signals. The signals may be down-converted utilizing a local oscillator signal generated by a phase locked loop (PLL), which may be delta-sigma modulated via a fractional-N divider. A clock signal may be communicated to the PLL utilizing a temperature-compensated crystal oscillator. The signals may be down-converted to an intermediate frequency or down-converted directly to baseband frequencies. The signals may be processed utilizing surface acoustic wave (SAW) filters. In-phase and quadrature signals may be processed in the RF path utilizing a two-stage polyphase filter.

20 Claims, 7 Drawing Sheets



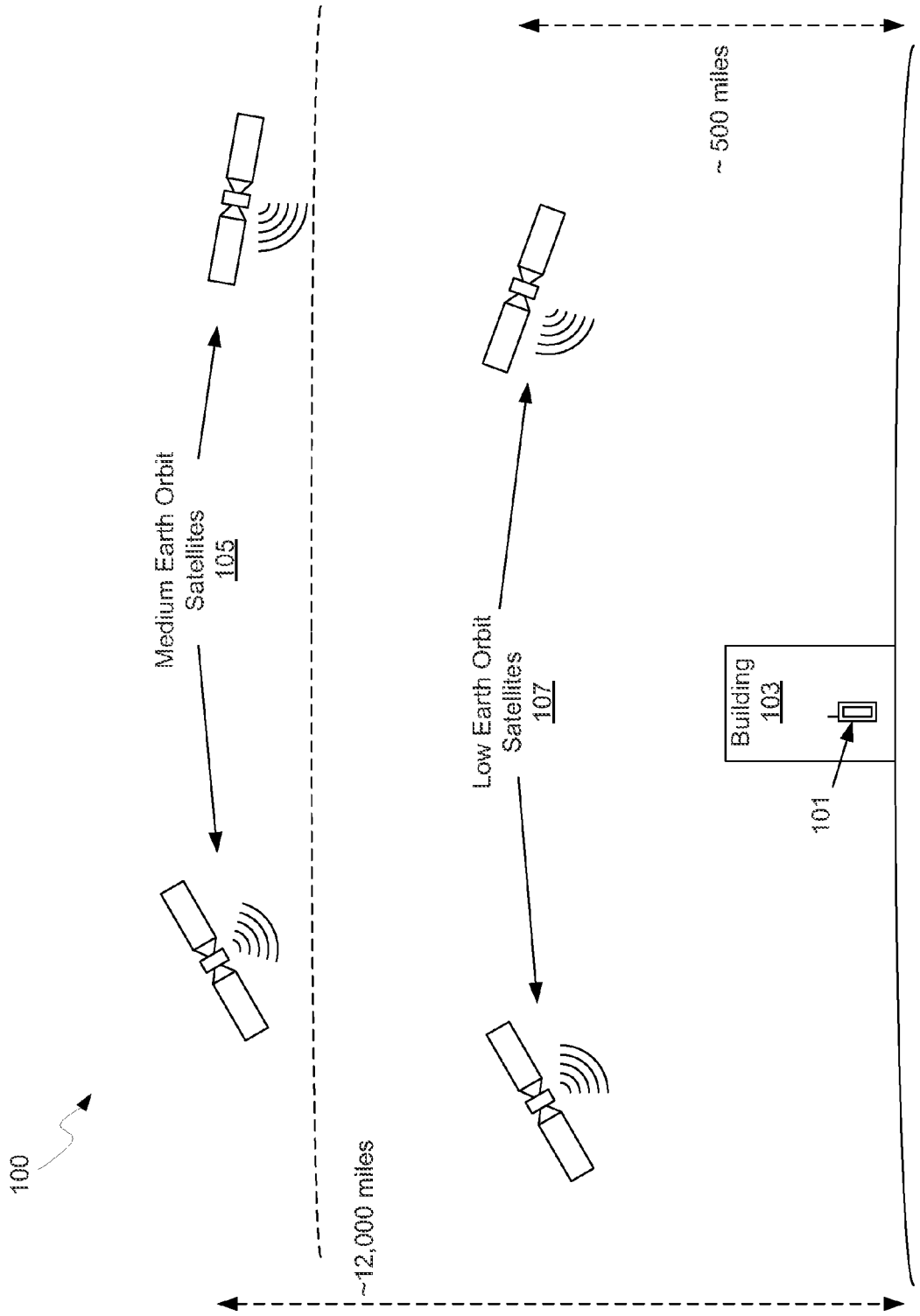

100
~12,000 miles
Medium Earth Orbit Satellites 105
Low Earth Orbit Satellites 107
~ 500 miles
Building 103
101

FIG. 1A

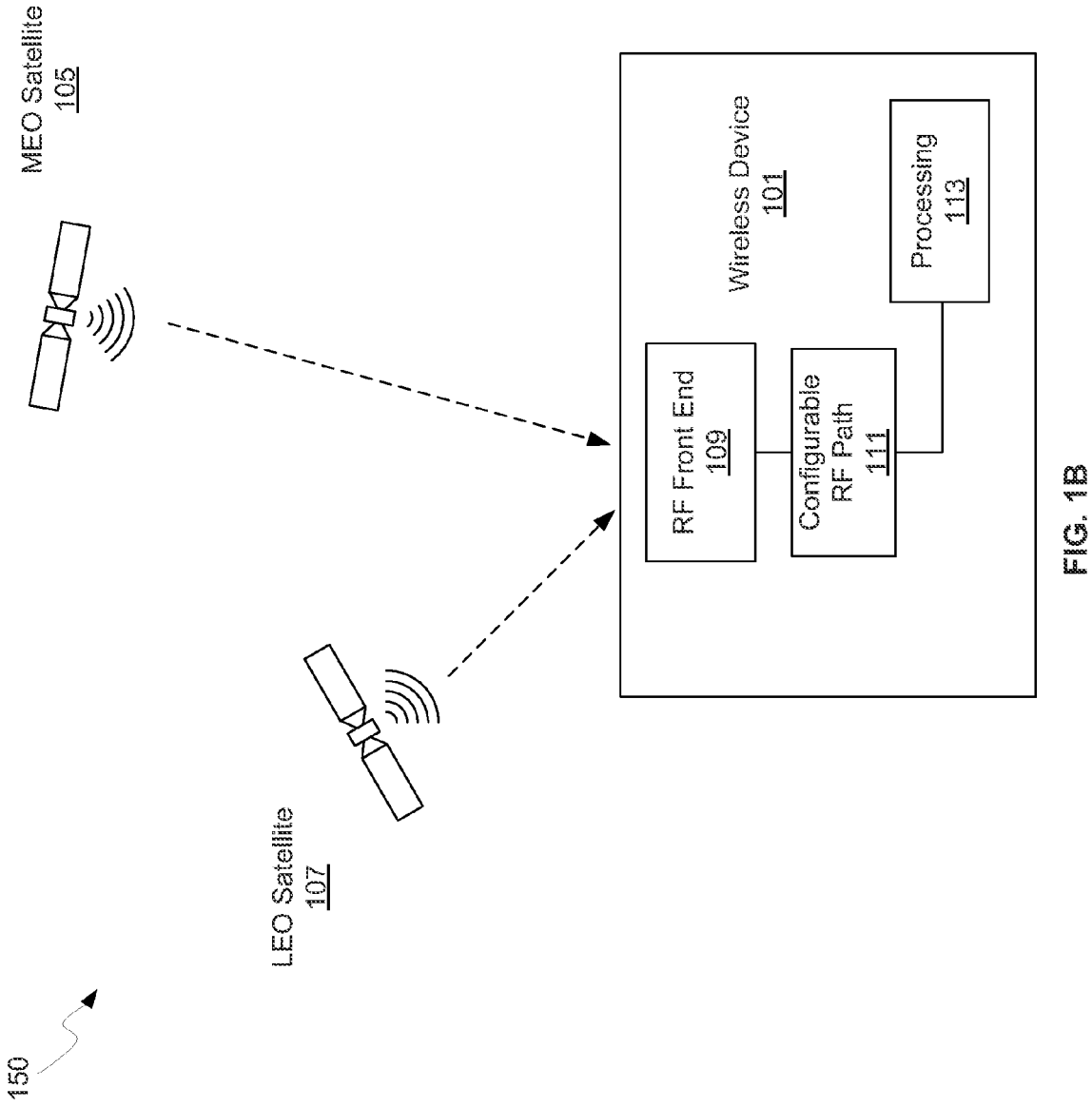

MEO Satellite
105
LEO Satellite
107
150
Wireless Device
101
RF Front End
109
Configurable
RF Path
111
Processing
113

FIG. 1B

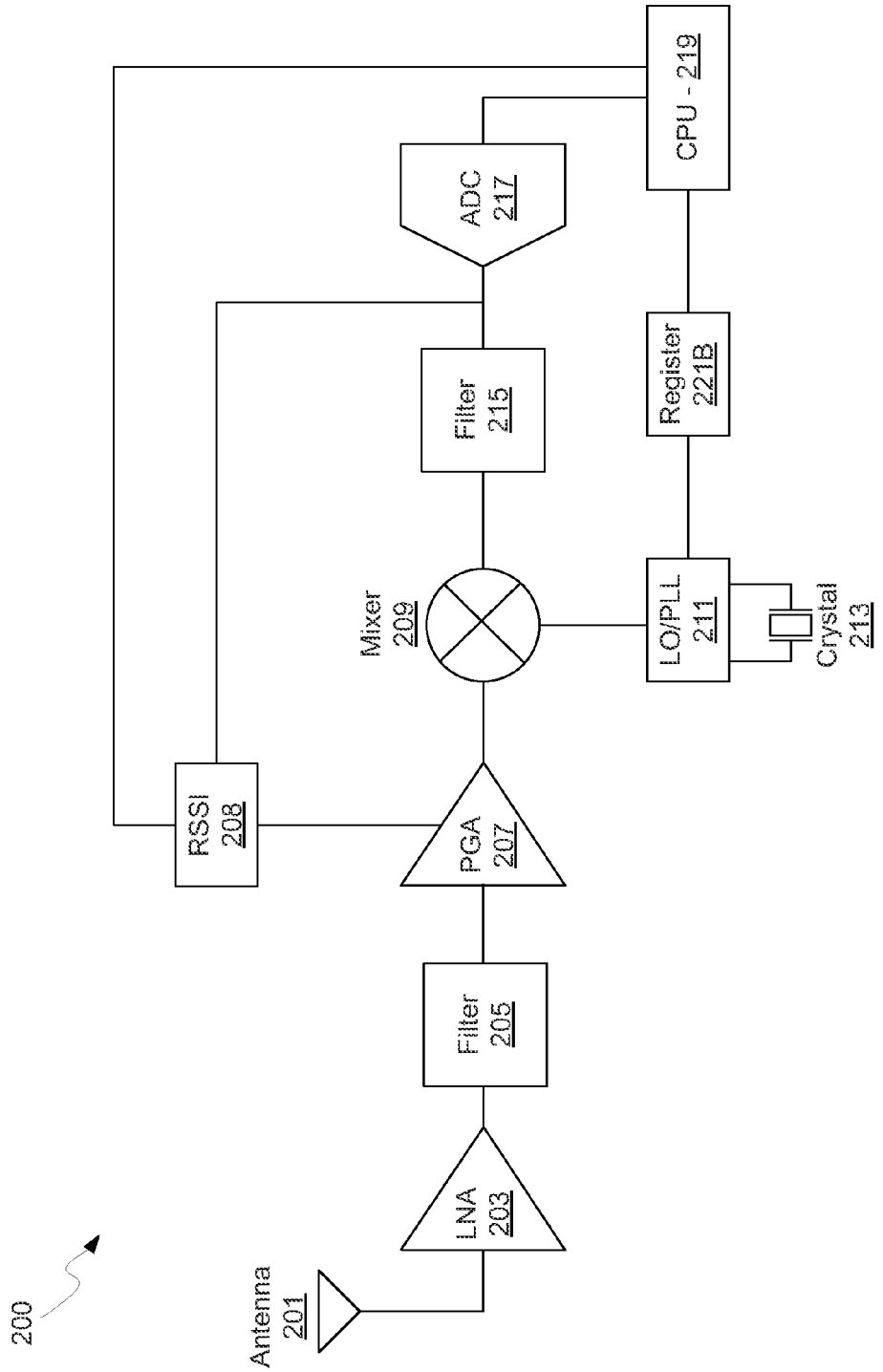

200
Antenna 201
LNA 203
Filter 205
PGA 207
RSSI 208
Mixer 209
LO/PLL 211
Crystal 213
Filter 215
ADC 217
CPU - 219
Register 221B

FIG. 2

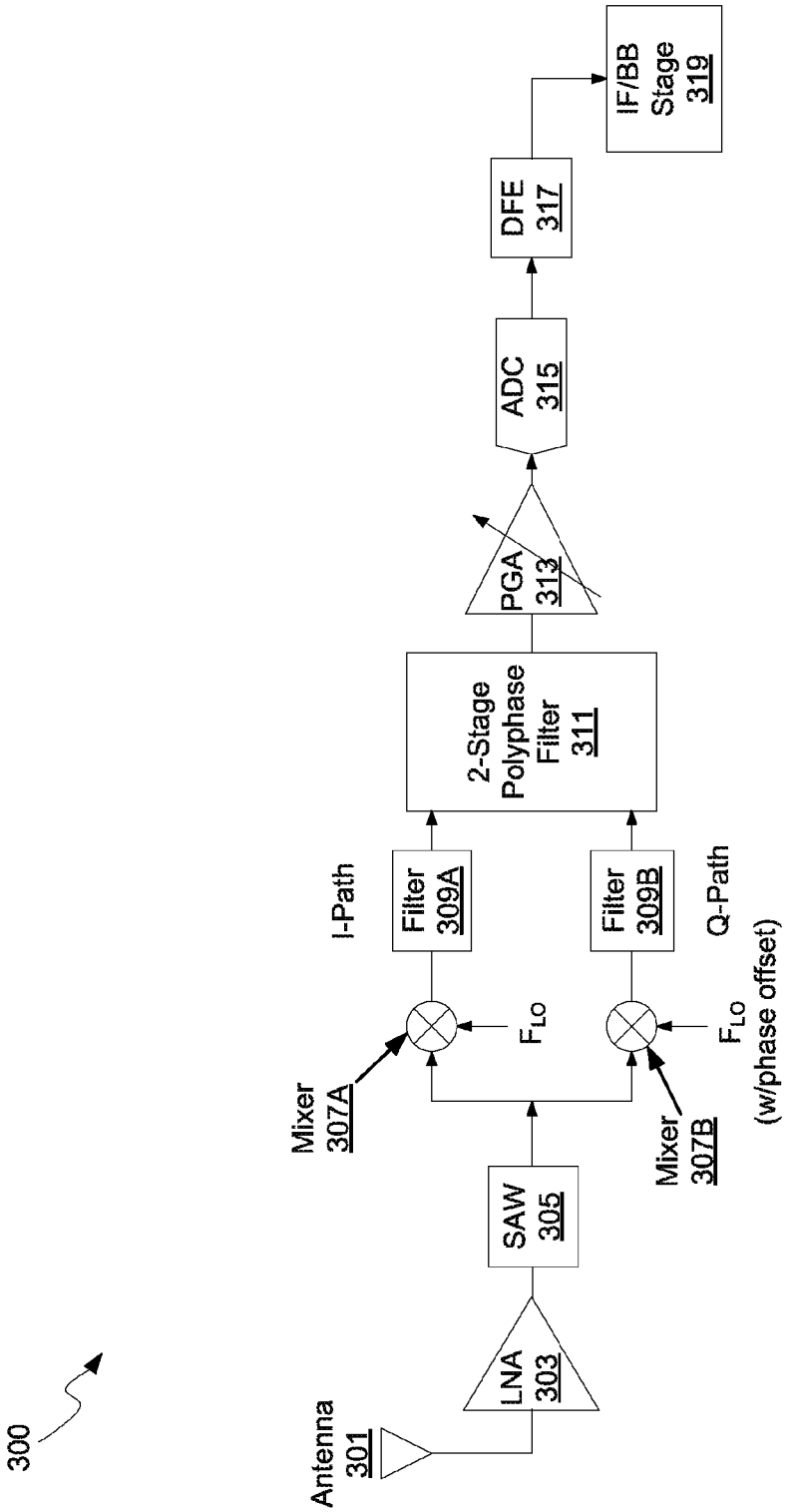

300
Antenna 301
LNA 303
SAW 305
Mixer 307A
Mixer 307B
F_{LO}
F_{LO} (w/phase offset)
I-Path
Q-Path
Filter 309A
Filter 309B
2-Stage Polyphase Filter 311
PGA 313
ADC 315
DFE 317
IF/BB Stage 319

FIG. 3

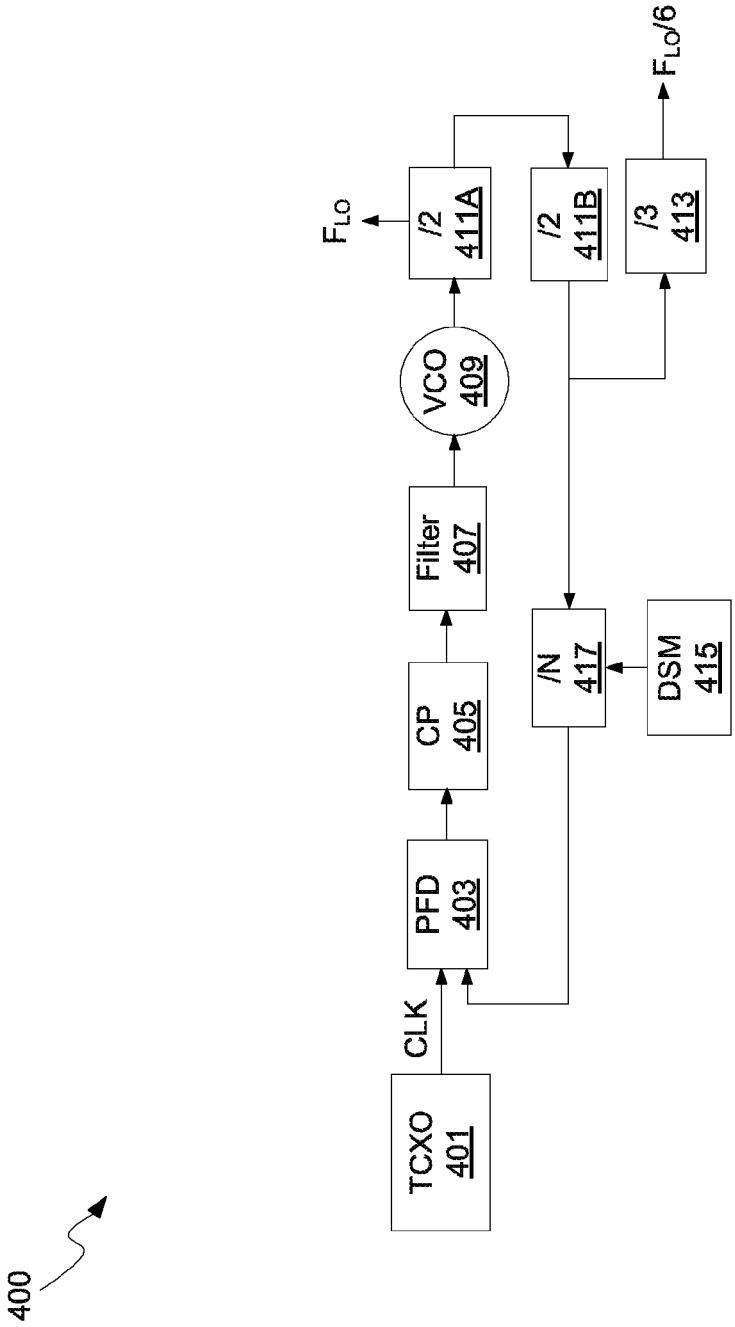

400
TCXO 401
CLK
PFD 403
CP 405
Filter 407
VCO 409
/2 411A
/2 411B
/3 413
/N 417
DSM 415
F_{LO}
$F_{LO}/6$

FIG. 4

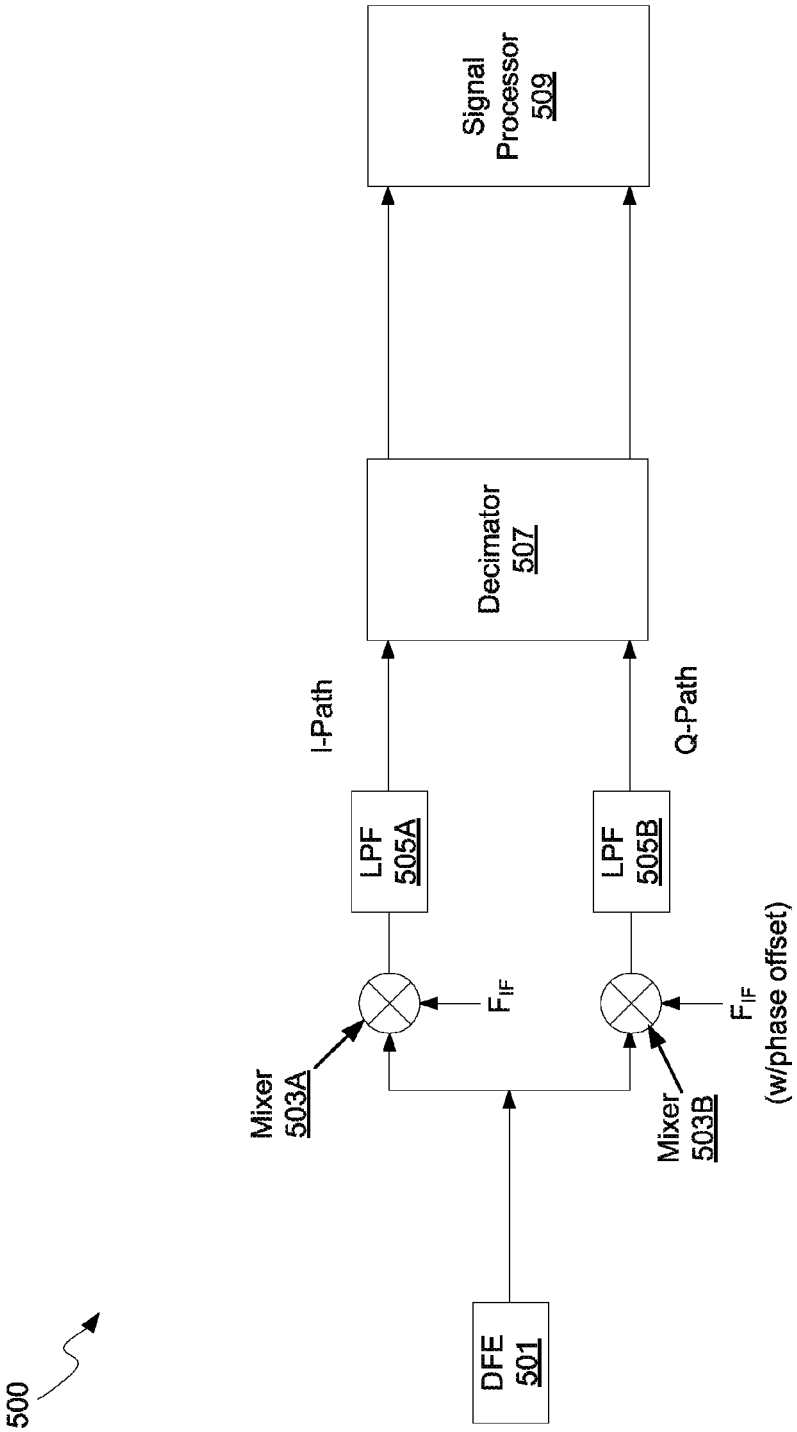

500
DFE 501
Mixer 503A
Mixer 503B
F_{IF}
F_{IF} (w/phase offset)
LPF 505A
LPF 505B
I-Path
Q-Path
Decimator 507
Signal Processor 509

FIG. 5

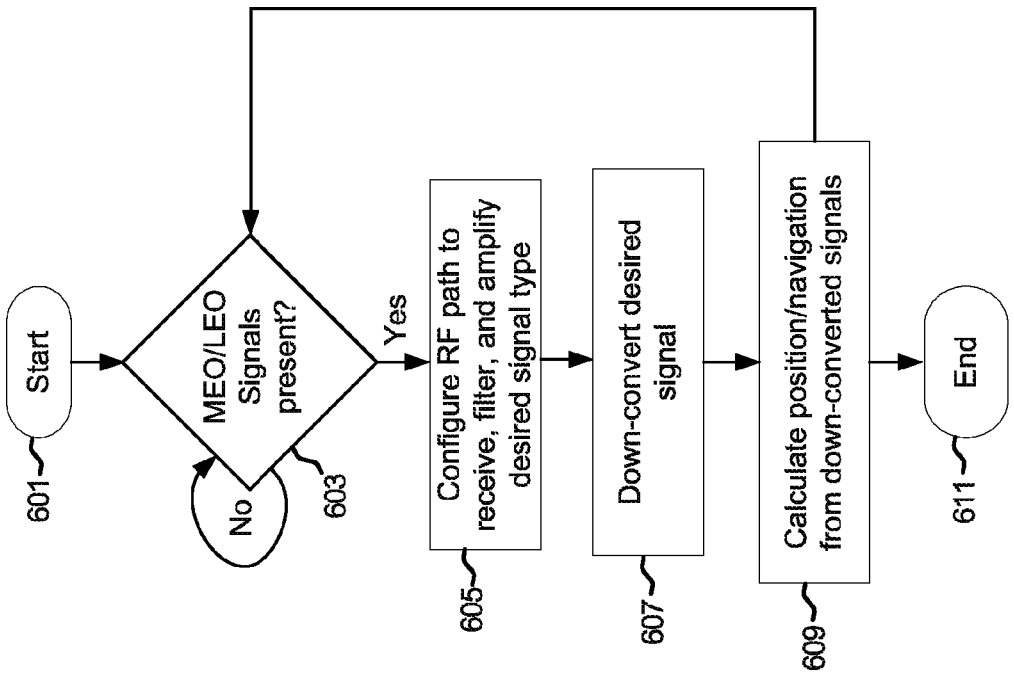

Start
601
MEO/LEO Signals present?
603
No
Yes
Configure RF path to receive, filter, and amplify desired signal type
605
Down-convert desired signal
607
Calculate position/navigation from down-converted signals
609
End
611

FIG. 6

METHOD AND SYSTEM FOR REPURPOSING OF A GLOBAL NAVIGATION SATELLITE SYSTEM RECEIVER FOR RECEIVING LOW-EARTH ORBIT COMMUNICATION SATELLITE SIGNALS

CROSS-REFERENCE TO RELATED APPLICATIONS/INCORPORATION BY REFERENCE

This application makes reference to and claims priority to U.S. Provisional Application Ser. No. 61/552,566 filed on Oct. 28, 2011, which is hereby incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

Certain embodiments of the invention relate to wireless communication. More specifically, certain embodiments of the invention relate to a method and system for repurposing of a global navigation satellite system receiver for receiving low-earth orbit communication satellite signals.

BACKGROUND OF THE INVENTION

Global navigation satellite systems (GNSS) such as the NAVSTAR global positioning system (GPS) or the Russian GLONASS provide accurate positioning information for a user anywhere on Earth that GNSS signals may be received. GNSS satellites are medium earth orbit satellites, about 12,000 miles above the surface. Highly accurate GNSS signals from these satellites may be used to accurately determine the position of a receiver and absolute time.

Further limitations and disadvantages of conventional and traditional approaches will become apparent to one of skill in the art, through comparison of such systems with the present invention as set forth in the remainder of the present application with reference to the drawings.

BRIEF SUMMARY OF THE INVENTION

A system and/or method for repurposing of a global navigation satellite system receiver for receiving low-earth orbit communication satellite signals, substantially as shown in and/or described in connection with at least one of the figures, as set forth more completely in the claims.

Various advantages, aspects and novel features of the present invention, as well as details of an illustrated embodiment thereof, will be more fully understood from the following description and drawings.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS

FIG. **1A** is a block diagram of an exemplary repurposed global navigation satellite system in accordance with an embodiment of the invention.

FIG. **1B** is a block diagram of an exemplary repurposed global navigation satellite system in accordance with an embodiment of the invention.

FIG. **2** is a diagram illustrating an exemplary radio frequency receiver, in accordance with an embodiment of the invention.

FIG. **3** is a diagram illustrating an exemplary in-phase and quadrature RF front end, in accordance with an embodiment of the invention.

FIG. **4** is a diagram illustrating an exemplary phase locked bop, in accordance with an embodiment of the invention.

FIG. **5** is a diagram illustrating an exemplary intermediate frequency path, in accordance with an embodiment of the invention.

FIG. **6** is a block diagram illustrating exemplary steps for repurposing of a global navigation satellite system receiver for receiving low-earth orbit communication satellite timing signals, in accordance with an embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Certain aspects of the invention may be found in a method and system for repurposing of a global navigation satellite system receiver for receiving low-earth orbit communication satellite timing signals. Exemplary aspects of the invention may comprise receiving medium Earth orbit (MEO) satellite signals and/or low Earth orbit (LEO) satellite signals in a receiver of the communication device. A radio frequency (RF) path may be configured to down-convert either the received LEO satellite signals or the received MEO satellite signals, and a position and absolute time of the wireless device may be calculated utilizing the down-converted signals. The received LEO satellite signals or the received MEO satellite signals may be down-converted utilizing a local oscillator signal generated by a phase locked loop (PLL), which may be delta-sigma modulated, for example, via a fractional-N divider. A clock signal may be communicated to the PLL utilizing a temperature-compensated crystal oscillator or a conventional crystal oscillator. The received LEO satellite signals or the received MEO satellite signals may be down-converted to an intermediate frequency before down-converting to baseband frequencies, or may be down-converted directly to baseband frequencies. The LEO satellite signals and/or the MEO satellite signals may be processed utilizing one or more surface acoustic wave (SAW) filters before down-conversion. In-phase and quadrature signals may be processed in the RF path. The in-phase and quadrature signals may be processed utilizing a two-stage polyphase filter in the RF path.

FIG. **1A** is a block diagram of an exemplary repurposed global navigation satellite system in accordance with an embodiment of the invention. Referring to FIG. **1**, there is shown a satellite navigation system **100** comprising a handheld communication device **101**, a building **103**, medium Earth orbit (MEO) satellites **105**, and low Earth orbit (LEO) satellites **107**. There is also shown the approximate height in miles of medium Earth and low Earth satellites of ~12,000 miles and ~500 miles, respectively.

The handheld communication device **101** may comprise any device or vehicle (e.g. smart phone) where its user may desire to know the location of such device or vehicle. The handheld communication device **101** may comprise a global navigation satellite system (GLASS) receiver having a configurable RF path that may be operable to receive medium Earth orbit (MEO) satellite signals and low Earth orbit (LEO) satellite signals.

There is also shown MEO satellites (e.g. GPS satellites) **105**, and LEO satellites (e.g. Iridium communication satellites) **107**. The MEO satellites **105** may be at a height of about 12,000 miles above the surface of the Earth, compared to about 500 miles above the surface for the LEO satellites **107**. Therefore, the signal strength of LEO satellite signals is much stronger than MEO satellite signals. The LEO satellites **107** may typically be used for telecommunication systems, such as satellite phones, whereas the MEO satellites **105** may be utilized for location and navigation applications.

In certain circumstances, MEO signals, such as GPS signals, may be attenuated by buildings or other structures to such an extent that GPS receivers cannot obtain a lock to any GPS satellites. However, due to the stronger signal strength of LEO satellite signals, the LEO signals may be utilized by devices to supplement or substitute the MEO systems in the devices. However, the frequencies utilized for MEO and LEO satellite communication are obviously not the same, so a conventional GPS receiver cannot process LEO signals, such as Iridium signals for example.

In an exemplary embodiment, a GPS receiver may be repurposed to receive LEO satellite signals, such as Iridium signals for example. In this manner, the receiver may be able to determine the user's location despite having high attenuation of GPS signals to below that of the sensitivity of the receiver. Thus, the handheld communication device **101** may be able to accurately determine its location by receiving both GPS and Iridium satellite signals even within the attenuating structure of the building **103**. This may be enabled by utilizing a configurable PLL to switch to a LEO satellite signal when MEO signals are attenuated by intervening structures, such as when the wireless device **101** is taken inside a building.

FIG. **1**B is a block diagram of an exemplary repurposed global navigation satellite system in accordance with an embodiment of the invention. Referring to FIG. **1**B, there is shown a MEO/LEO navigation system **150** comprising the MEO satellites **105**, the LEO satellites **107**, and the wireless device **101**. The wireless device **101** may comprise an RF front end **109**, a configurable MEO/LEO RF path **111**, and a processing block **113**.

The RF front end **109** may comprise elements such as antennas, low-noise amplifiers (LNAs), filters, and signal splitters, for example. The RF front end **109** may thus be operable to receive, amplify, and filter RF signals for subsequent processing by the configurable RF path **111**. Accordingly, the RF front end **109** may comprise a wide enough bandwidth to receive and process both LEO and MEO signals concurrently.

The configurable MEO/LEO RF path **111** may comprise amplification, down-conversion, filtering, and analog-to-digital conversion capability for received MEO and LEO signals. In this manner, the wireless device **101** may be configured to utilize either MEO or LEO satellite signals for positioning, navigation, and timing. Aspects of this are described further with respect to FIGS. **2**-**4**.

The processing block **113** may comprise one or more CPUs (e.g. a RISC CPU or digital signal processor (DSP)) for demodulating signals and calculating positioning information, for example. The processing block **113** may be operable to configure the gain levels of amplifiers in the RF front end **109** or configure filter characteristics for improved signal to noise ratio, for example.

In operation, the wireless device **101** may be operable to receive both LEO and MEO satellite signals and configure an RF path to select the desired signal for positioning and navigation services. For example, if the wireless device **101** is utilizing MEO satellite signals for navigation but then enters a structure that attenuates MEO signals below a sensitivity threshold, the configurable MEO/LEO path **111** may be configured to down-convert LEO signals for positioning and navigation purposes. The processing block **113** may utilize a received signal strength indicator (RSSI) to determine that the MEO signals are inadequate for positioning and navigation purposes, and subsequently configure the configurable MEO/LEO path **111** to switch to LEO signals.

FIG. **2** is a diagram illustrating an exemplary radio frequency receiver, in accordance with an embodiment of the invention. Referring to FIG. **2**, there is shown a receiver **200** comprising an antenna **201**, a low noise amplifier (LNA) **203**, a filter module **205**, a programmable gain amplifier (PGA) **207**, a receive signal strength indicator (RSSI) **208**, a mixer **209**, a local oscillator (LO)/phase locked loop (PLL) **211**, a crystal oscillator **213**, a filter module **215**, an analog-to-digital converter (ADC) **217**, a central processing unit **219**, and a register **221**B.

The antenna **201** may be operable to receive RF signals for subsequent processing by the other elements of the receiver **200**. The antenna **201** may comprise a single antenna with wide enough bandwidth to receive both LEO and MEO signals, may comprise a tunable antenna to cover the desired frequency range, or may comprise more than one antenna for receiving signals, each for receiving signals in one of a plurality of frequency ranges.

The LNA **203** may be operable to provide amplification to the signals received by the antenna **201**, with the amplified signal being communicated to the filter **205**. Similarly, the PGA **207** may provide amplification to signals received from the filter module **205**. The filter module **205** may comprise active and/or passive filters for removing unwanted signals while allowing desired signals to pass to the PGA **207**. In an exemplary scenario, the filter module **205** comprises a surface acoustic wave (SAW) filter. The PGA **207** may be configured by a processor, such as the CPU **219**.

The RSSI module **208** may comprise circuitry for determining the magnitude of a received signal, and may sense signal strengths at the PGA **207** or for down-converted signals after the filter **215**, for example. Accordingly, the RSSI module **208** may be operable to sense signal strength at any point along the receiver **200** and may be coupled to the CPU **219** for configuring gain levels in the RF path, for example, from the measured RSSI levels.

The mixer **209** may comprise circuitry that is operable to generate output signals at frequencies that are the sum and the difference between the input RF signal and the local oscillator signal received from the LO/PLL **211**. The frequency of LO_I and LO_Q may be configured such that the desired signal is at baseband such that unwanted higher frequency signals may be filtered out by a low pass filter, such as the filter module **215**.

In another exemplary scenario, the mixer **209** may down-convert the received RF signals to an intermediate frequency (IF) for further processing, as opposed to down-converting directly to baseband. In this scenario, the filter module **215** may comprise a bandpass filter that is configured to pass the desired IF signals while filtering out the undesired low and high frequency signals.

The LO/PLL **211** may comprise circuitry that is operable to generate an RF signal to enable down-conversion of RF signals received by the mixer **209**. The LO/PLL **211** may comprise a voltage-controlled oscillator, for example, with a PLL to stabilize the frequency of the output signal communicated to the mixer **209**.

The crystal oscillator **213** may comprise a stable clock source for the receiver **200**, and may comprise a piezoelectric crystal, for example, that outputs a stable clock signal at a given temperature.

The ADC **217** may comprise circuitry that is operable to convert analog input signals to digital output signals. Accordingly, the ADC **217** may receive baseband or IF analog signals from the mixer **209** and may generate digital signals to be communicated to the CPU **219**.

The CPU **219** may comprise a processor similar to the processor **113**, for example, described with respect to FIG. **1**. Accordingly, the CPU **219** may be operable to control the

functions of the receiver **200** and may process received baseband or IF signals to demodulate, decode, and/or perform other processing techniques to the received data. Other processing techniques may comprise positioning calculations based on received satellite signals. The CPU **219** may thus be operable to demodulate and decode both MEO and LEO satellite data, such as GPS and Iridium data for example. In an exemplary scenario, the CPU **219** may be accelerated with dedicated hardware, not shown, such as fast Fourier transform (FFT) engines and correlators, for example.

The register **221**B may comprise a memory register for storing a configuration to be communicated to the LO/PLL to down-convert MEO or LEO signals. The register **221**B may communicate an output signal to the LO/PLL **211** that indicates the desired frequency signal to down-convert to IF or baseband.

In an exemplary scenario, the receiver may comprise two separate RF paths for processing in-phase and quadrature (I and Q) signals, as described further with respect to FIG. **3** for example.

FIG. **3** is a diagram illustrating an exemplary in-phase and quadrature RF front end, in accordance with an embodiment of the invention. Referring to FIG. **3**, there is shown the I and Q RF path **300** comprising an antenna **301**, an LNA **303**, a SAW filter **305**, mixers **307**A and **307**B, filters **309**A and **309**B, a 2-stage polyphase filter **311**, a PGA **313**, an ADC **315**, a digital front end (DFE) **317**, and an IF/baseband stage **319**. The antenna **301**, the LNA **303**, the SAW filter **305**, the mixers **307**A and **307**B, the filters **309**A and **309**B, the PGA **313**, and the ADC **315** may be substantially similar to similarly named elements described with respect to FIG. **2**.

The mixers **307**A and **307**B may receive input signals from the SAW filter **305** and local oscillator signals at frequency F_{LO}, and 90 degree phase difference, to down-convert the received I and Q signals.

The 2-stage polyphase filter **311** may comprise circuitry for providing I and Q signal image rejection of intermediate or baseband signals received from the filters **309**A and **309**B. This has an advantage over integrating filters prior to the mixers **307**A and **307**B to reduce image signals because this would require very high Q factors. The 2-stage polyphase filter **311** may comprise a notch frequency of $-F_{IF}$.

In an exemplary scenario, the ADC **315** may comprise a sigma-delta converter. The DFE **317** may comprise circuitry that is operable to decimate the digital signal received from the ADC **315**. In an exemplary scenario, the ADC **315** may generate a 1-bit output signal at a frequency F_{ADC}, and the DFE **317** may then decimate the received signal by 16 to result in a 6 bit IF signal with a sampling frequency of $F_{LO}/96$.

The IF/baseband stage **319** may comprise circuitry for further processing of the IF or baseband signals received from the DFE **317**. For example, if the DFE **317** output signal is an IF signal, the IF/baseband stage **319** may comprise further down-conversion capability. In addition, the IF/baseband stage **319** may comprise filtering and decimation capability for further processing of the received signals.

In operation, the I and Q RF path **300** may receive an RF signal via the antenna **301**. The LNA **303** may provide amplification to the received signal before being filtered by the SAW filter **305**. The SAW filter **305** may comprise a filter with wide enough bandwidth for both LEO and MEO signals or may be configurable to different frequency ranges. In another exemplary scenario, the SAW filter **305** may comprise a plurality of filters that may be selectively enabled so that only desired signals are passed to the mixers **307**A and **307**B.

The mixers **307**A and **307**B may receive the filtered RF signals and local oscillator signals F_{LO} that are 90 degrees out of phase for down-converting I and Q signals to IF or baseband frequencies. The resulting IF or baseband signals may be filtered by the filters **309**A and **309**B and the 2-stage polyphase filter **311** before being amplified by the PGA **313**. The 2-stage polyphase filter **311** may provide image rejection in instances where image signals interfere with the desired signals. The PGA **313** may receive a gain control signal from a processor, such as the CPU **219** described with respect to FIG. **2**.

The ADC **315** may convert the amplified and filtered IF/baseband signal to a digital signal for further processing in the digital domain. For example, the DFE **317** and the IF/baseband stage **319** may decimate and filter the digital signal received from the ADC **315**. In addition, the IF/baseband stage **319** may comprise a positioning engine for determining the location of the wireless device comprising the I and Q RF front end **300**. The position may be determined from accurate timing signals received from a plurality of LEO or MEO satellite signals in conjunction with ephemeris data for the satellites.

FIG. **4** is a diagram illustrating an exemplary phase locked loop, in accordance with an embodiment of the invention. Referring to FIG. **4**, there is shown a phase locked loop (PLL) **400** comprising a temperature-compensated crystal oscillator (TXCO) **401**, a phase-frequency detector (PFD) **403**, a charge pump **405**, a loop filter **407**, a voltage-controlled oscillator (VCO) **409**, divide-by-2 modules **411**A and **411**B, a divide-by-3 module **413**, a delta-sigma modulator (DSM) **415**, and a fractional-N divider **417**. There is also shown a clock signal CLK and output signals F_{LO} and $F_{LO}/6$.

The TCXO **401** may comprise a crystal oscillator that is capable of providing a stable clock signal, CLK, over an operational temperature range. The TCXO **401** may thus provide the base clock signal for the PLL **400** that is communicated to the PFD **403**.

The PFD **403** may comprise circuitry that is operable to sense a phase difference between received input signals, such as the signals received from the TCXO **401** and the fractional-N divider **417**. The PFD **403** may output a phase error signal, which is proportional to the phase difference between the two input signals. This error signal may be communicated to the charge pump **405** for adjustment purposes.

The charge pump **405** may comprise circuitry that is operable to adjust a frequency of the VCO **409** via the filter **407**. The charge pump **405** may receive an error signal from the PFD **403** that is proportional to the phase difference between input clock signals. Accordingly, the charge pump **405** may generate an output signal that increases or decreases the oscillation frequency of the VCO **409**.

The loop filter **407** may comprise a low-pass filter, for example, that filters out noise signals and allows a control signal to pass from the charge pump **405** to the VCO **409**. Removing spurious signals and noise fluctuations may increase the stability of the PLL **400**.

The VCO **409** may comprise circuitry that is operable to generate a clock signal at a frequency configured by an input voltage. Accordingly, the frequency of the output signal generated by the VCO **409** may be proportional to the magnitude of the voltage of the input signal received from the charge pump **405** via the loop filter **407**. The output signal may then be communicated to the divide-by-2 modules **411**A and **411**B, which may comprise frequency dividers. The divide-by-2 module **411**A may generate an output signal F_{LO}, which may correspond to the F_{LO}, described with respect to FIG. **3**, and may also communicate an output signal to the divide-by-2 module **411**B for a second halving of the frequency.

The divide-by-2 module **411**B may communicate an output signal to the divide-by-3 module **413** and the fractional-N divider **417**. The divide-by-3 module **413** may divide the frequency again by 3, resulting in an output signal $F_{LO}/6$. The fractional-N divider **417** may divide the frequency of the input signal by a configurable factor, thereby enabling accurate frequency control of the PLL **400** over a plurality of steps in a frequency range.

The fractional-N divider **417** may receive a modulus control signal from the DSM **415**. The value of N may be configured to hop between two values so that the VCO **409** alternates between one locked frequency and the other. The VCO **409** may then stabilize at a frequency that is the time average of the two locked frequencies. By varying the percentage of time that the fractional-N divider **417** spends at the two divider values, the frequency of the locked VCO **409** may be configured with very fine granularity.

In an exemplary scenario, the DSM **415** may enable the PLL **400** to hop between frequencies in a pseudo-random fashion to create noise shaping that reduces the phase noise of the system. The PLL **400** may thus be operable to provide a plurality of stable clock signals based on a TCXO output, and with small incremental steps in output frequency configured by the fractional-N divider **417**. The output of the divide-by-3 module **413** may comprise a clock signal for the ADC **315**, for example, as described with respect to FIG. **3**.

FIG. **5** is a diagram illustrating an exemplary intermediate frequency path, in accordance with an embodiment of the invention. Referring to FIG. **5**, there is shown an IF path **500** comprising a DFE **501**, mixers **503**A and **503**B, low-pass filters **505**A and **505**B, a decimator **507**, and a signal processor **506**.

The IF path **500** may correspond to the DFE **317** and the IF/baseband stage **319** as described with respect to FIG. **3**, for example. Similarly, the mixers **503**A and **503**B may be substantially similar to the mixers **307**A and **307**B of FIG. **3**, for example, but with different local oscillator frequencies. For example, the mixers **503**A and **503**B may receive local oscillator signals F_{IF}, and F_{IF} with a 90 degree phase shift, respectively, to down-convert an IF signal to baseband for further processing by the decimator **507** and the signal processor **509**.

The LPFs **505**A and **505**B may be operable to filter out higher frequency signals while allowing low frequency, or baseband, signals to pass. The decimator **507** may comprise circuitry that is operable to reduce the sampling rate of the digital input signal. For example, the decimator **507** may decimate the sampling rate by a factor of 64, before communicating the resulting signal to the signal processor **509**.

The signal processor **509** may comprise a CPU, for example, that may be operable to calculate positioning and navigation information from received satellite signals. For example, the signal processor **509** may comprise an assisted-GPS positioning engine that is operable to calculate the position of the wireless device **101** from received LEO or MEO satellite signals and stored and/or retrieved ephemeris data.

By enabling the down-conversion of both MEO and LEO signals, the signal processor **509** may determine position and navigation information in areas where MEO signals are too attenuated. Similarly, the signal processor **509** may alternate between MEO and LEO signal data or use data from one signal type to assist in the positioning calculation and/or timing synchronization of the other type of signal. The configuration of a wireless device to receive both LEO and MEO signals may greatly reduce space requirements as the configurable RF path **111** may be integrated on a single chip, as opposed to multiple RF paths, each for a different signal type.

In addition, using timing information from the strongest system may significantly help the weaker system to acquire its signals and thus improve overall performance, such as when MEO signals are weak, where the LEO signals may be used to assist the MEO system.

FIG. **6** is a block diagram illustrating exemplary steps for repurposing of a global navigation satellite system receiver for receiving low-earth orbit communication satellite timing signals, in accordance with an embodiment of the invention. The exemplary method illustrated in FIG. **6** may, for example, share any or all functional aspects discussed previously with regard to FIGS. **1**-**5**.

Referring to FIG. **6**, after start step **601**, in step **603**, the wireless device may determine whether LEO and/or MEO signals are present. If yes, the exemplary steps may proceed to step **605** where the RF path may be configured to receive, filter, and amplify the desired signal type. In step **607**, the received, filtered, and amplified signal may be down-converted to IF to subsequently be converted to baseband frequencies, or may be down-converted directly to baseband frequencies. The local oscillator signal for the down-conversion may be generated via a delta-sigma modulated phase locked loop (DSM PLL), such that both LEO and MEG signal frequencies may be received and down-converted.

In step **609**, the received and down-converted signals may be demodulated and decoded to extract accurate timing information for calculating the position of the wireless device. This is followed by end step **611**.

In an embodiment of the invention, a method and system may comprise receiving medium Earth orbit (MEO) satellite signals and/or low Earth orbit (LEO) satellite signals in a receiver of the communication device **101**. A radio frequency (RF) path **200**, **300** may be configured to down-convert either the received LEO satellite signals or the received MEO satellite signals, and a position of the wireless device **101** may be calculated utilizing the down-converted signals. Absolute time of the communication device **101** may be synchronized utilizing the down-converted signals.

The received LEO satellite signals or the received MEO satellite signals may be down-converted utilizing a local oscillator signal F_{LO} generated by a phase locked loop (PLL) **211**, **400**, which may be delta-sigma modulated **415** via a fractional-N divider **417**. A clock signal CLK may be communicated to the PLL **211**, **400** utilizing a temperature-compensated crystal oscillator **401**. The received LEO satellite signals or the received MEO satellite signals may be down-converted to an intermediate frequency before down-converting to baseband frequencies, or may be down-converted directly to baseband frequencies.

The LEO satellite signals and/or the MEO satellite signals may be processed utilizing one or more surface acoustic wave (SAW) filters **305**. In-phase and quadrature signals, I-Path and Q-Path, may be processed in the RF path **300**. The in-phase and quadrature signals may be processed utilizing a two-stage polyphase filter **311** in the RF path **300**.

Other embodiments of the invention may provide a non-transitory computer readable medium and/or storage medium, and/or a non-transitory machine readable medium and/or storage medium, having stored thereon, a machine code and/or a computer program having at least one code section executable by a machine and/or a computer, thereby causing the machine and/or computer to perform the steps as described herein for repurposing of a global navigation satellite system receiver for receiving low-earth orbit communication satellite signals.

Accordingly, aspects of the invention may be realized in hardware, software, firmware or a combination thereof. The

invention may be realized in a centralized fashion in at least one computer system or in a distributed fashion where different elements are spread across several interconnected computer systems. Any kind of computer system or other apparatus adapted for carrying out the methods described herein is suited. A typical combination of hardware, software and firmware may be a general-purpose computer system with a computer program that, when being loaded and executed, controls the computer system such that it carries out the methods described herein.

One embodiment of the present invention may be implemented as a board level product, as a single chip, application specific integrated circuit (ASIC), or with varying levels integrated on a single chip with other portions of the system as separate components. The degree of integration of the system will primarily be determined by speed and cost considerations. Because of the sophisticated nature of modern processors, it is possible to utilize a commercially available processor, which may be implemented external to an ASIC implementation of the present system. Alternatively, if the processor is available as an ASIC core or logic block, then the commercially available processor may be implemented as part of an ASIC device with various functions implemented as firmware.

The present invention may also be embedded in a computer program product, which comprises all the features enabling the implementation of the methods described herein, and which when loaded in a computer system is able to carry out these methods. Computer program in the present context may mean, for example, any expression, in any language, code or notation, of a set of instructions intended to cause a system having an information processing capability to perform a particular function either directly or after either or both of the following: a) conversion to another language, code or notation; b) reproduction in a different material form. However, other meanings of computer program within the understanding of those skilled in the art are also contemplated by the present invention.

While the invention has been described with reference to certain embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted without departing from the scope of the present invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the present invention without departing from its scope. Therefore, it is intended that the present invention not be limited to the particular embodiments disclosed, but that the present invention will include all embodiments falling within the scope of the appended claims.

What is claimed is:

1. A method for wireless communication, the method comprising:

in a communication device that is capable of receiving both medium Earth Orbit (MEO) satellite signals and low Earth orbit (LEO) satellite signals:

receiving MEO satellite signals and/or LEO satellite signals in a receiver of said communication device;

configuring a radio frequency (RF) path to down-convert either said received LEO satellite signals or said received MEO satellite signals;

calculating a position of said wireless device utilizing said down-converted signals; and

synchronizing local time of said communication device utilizing said down-converted signals.

2. The method according to claim **1**, comprising down-converting said received LEO satellite signals or said received MEO satellite signals utilizing a local oscillator signal generated by a phase locked loop (PLL).

3. The method according to claim **2**, comprising delta-sigma modulating said PLL.

4. The method according to claim **2**, comprising delta-sigma modulating said PLL via a fractional-N divider.

5. The method according to claim **2**, comprising communicating a clock signal to said PLL utilizing a temperature-compensated crystal oscillator.

6. The method according to claim **1**, comprising down-converting said received LEO satellite signals or said received MEO satellite signals to an intermediate frequency before down-converting to baseband frequencies.

7. The method according to claim **1**, comprising down-converting said received LEO satellite signals or said received MEO satellite signals directly to baseband frequencies.

8. The method according to claim **1**, comprising processing said LEO satellite signals and/or said MEO satellite signals utilizing one or more surface acoustic wave (SAW) filters.

9. The method according to claim **1**, comprising processing in-phase and quadrature signals in said RF path.

10. The method according to claim **1**, comprising processing said in-phase and quadrature signals utilizing a two-stage polyphase filter in said RF path.

11. A system for wireless communication, the system comprising:

one or more circuits for use in a communication device that is capable of receiving both medium Earth Orbit (MEO) satellite signals and low Earth orbit (LEO) satellite signals, said one or more circuits being operable to:

receive MEO satellite signals and/or LEO satellite signals in a receiver of said communication device;

configure a radio frequency (RF) path to down-convert either said received LEO satellite signals or said received MEO satellite signals;

calculate a position of said wireless device utilizing said down-converted signals; and

synchronize local time of said communication device utilizing said down-converted signals.

12. The system according to claim **11**, wherein said one or more circuits are operable to down-convert said received LEO satellite signals or said received MEO satellite signals utilizing a local oscillator signal generated by a phase locked loop (PLL).

13. The system according to claim **12**, wherein said one or more circuits are operable to delta-sigma modulate said PLL.

14. The system according to claim **12**, wherein said one or more circuits are operable to delta-sigma modulate said PLL via a fractional-N divider.

15. The system according to claim **12**, wherein said one or more circuits are operable to communicate a clock signal to said PLL utilizing a temperature-compensated crystal oscillator.

16. The system according to claim **11**, wherein said one or more circuits are operable to down-convert said received LEO satellite signals or said received MEO satellite signals to an intermediate frequency before down-converting to baseband frequencies.

17. The system according to claim **11**, wherein said one or more circuits are operable to down-convert said received LEO satellite signals or said received MEO satellite signals directly to baseband frequencies.

18. The system according to claim **11**, wherein said one or more circuits are operable to process said LEO satellite signals and/or said MEO satellite signals utilizing one or more surface acoustic wave (SAW) filters.

19. The system according to claim 11, wherein said one or more circuits are operable to process in-phase and quadrature signals in said RF path.

20. A system for wireless communication, the system comprising:

one or more circuits for use in a communication device that is capable of receiving both medium Earth Orbit (MEO) satellite signals and low Earth orbit (LEO) satellite signals, said one or more circuits being operable to:

receive MEO satellite signals and/or LEO satellite signals in a receiver of said communication device;

configure a radio frequency (RF) path to down-convert either said received LEO satellite signals or said received MEO satellite signals;

process in-phase and quadrature signals in said RF path;

calculate a position of said wireless device utilizing said down-converted signals; and

synchronize local time of said communication device utilizing said down-converted signals.

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